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Subcommittee on Space Science and Applications

Committee on Science, Space, and Technology

House of Representatives

Statement by:
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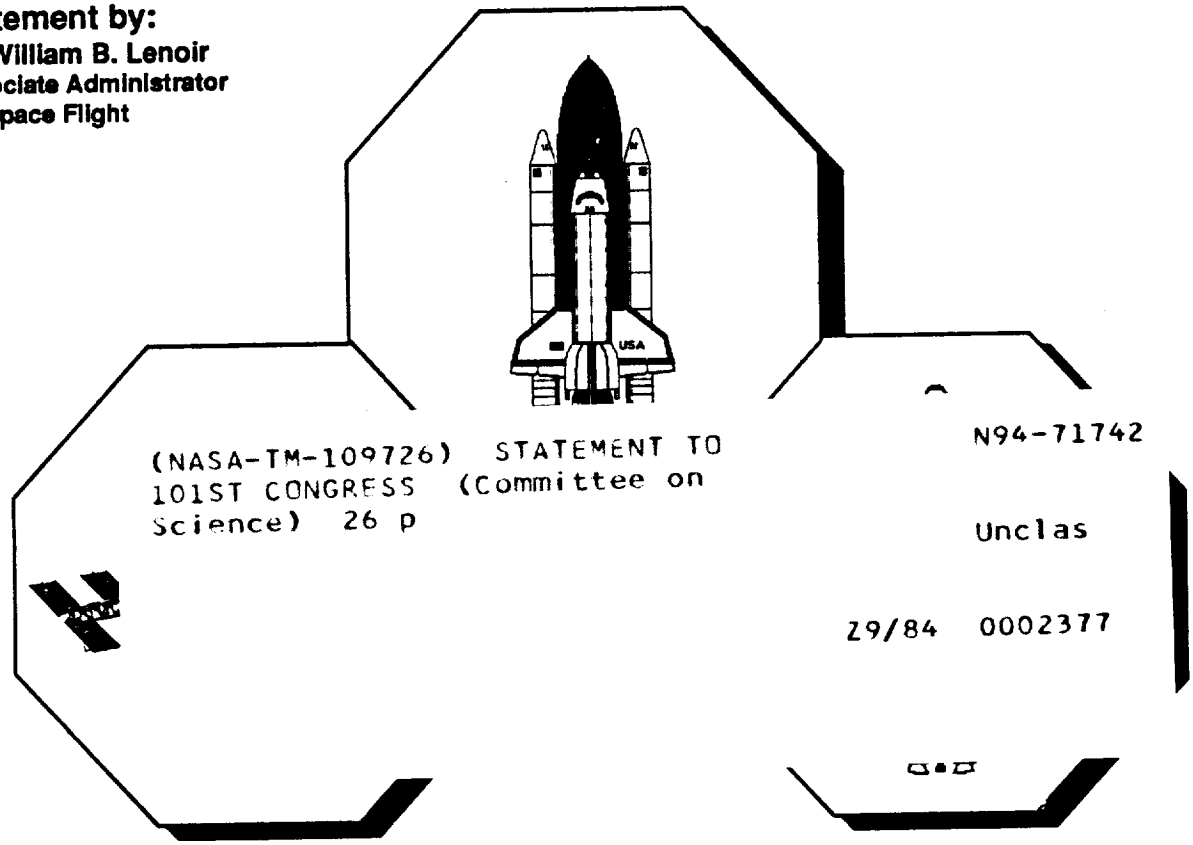
Associate Administrator for Space Flight



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101st Congress

Mr. Chairman and Members of the Subcommittee:

I am pleased to be here today to discuss the Space Station Freedom program.

The mission of the Space Station Freedom program is to develop and operate a multipurpose manned orbital facility beginning in the mid-1990s. We are aggressively moving forward to meet that goal, and our first element launch is now only five years away. 1989 was our first full year of preliminary design activities. Together with our international partners, we made significant progress in designing systems and elements in all areas of the Space Station program. These design efforts were complemented by the fabrication and testing of numerous development hardware articles.

In the last quarter of FY 1989, we conducted a series of configuration/budget reviews to realign the Space Station program with the anticipated near-term funding reduction from Congress. These reviews included participation by all levels of the Space Station program, the user offices at NASA Headquarters, our international partners, and the prime contractors. The program adjustments that resulted from these reviews accommodated Congressional directions for reduced funding, while successfully maintaining both the configuration of the baseline Space Station and the integrity of its capabilities and reducing sources of technical and schedule risk.

Our activities this year are directed at completing the preliminary design of most Space Station systems and elements. We have implemented the program adjustments discussed at the October 31 hearing of the full committee, and we are now preparing for a series of Preliminary Design Reviews (PDR's) later this year. These reviews will culminate with a program-level PDR in December. Our schedule for these reviews is shown on Attachment 1. Our development hardware fabrication and testing efforts continue to support the design process.

This year we are also transferring management of the Polar Platform from the Office of Space Flight to the Office of Space Science and Applications. This decision was made to meet the unique requirements of the planned Earth Observing System (EOS) mission. Transferring the Polar Platform to the Office of Space Science and Applications will ensure maximum responsiveness to the requirements of the EOS user community. We will honor our agreements with our international partners in all respects in the implementation of this transfer.

We have taken steps to strengthen the involvement of users in the development program. The Office of Space Science and Applications, the Office of Aeronautics and Space Technology, and the Office of Commercial Programs are now members of the

Level II Space Station Control Board, in addition to their membership on the Level I Program Control Board. Since these two boards control requirements levied on the work package centers and the program office respectively, the user community has greater and more direct involvement in the Space Station decision process.

Several major studies are in progress to make sure we are effectively spending funds on the needed user capabilities. For example, we are reviewing requirements for laboratory support equipment with the Office of Space Science and Applications and other user offices to determine what equipment is required and which office should develop it.

Our international partners are involved in the management of the program consistent with the international agreements. We are continuing to work closely with them to coordinate our tightly coupled design and development efforts. Together, we have put into place partner liaison offices in Reston and NASA liaison offices at the international partners' sites to provide an effective mechanism for day-to-day communication at the working level of the program. This action complements our frequent meetings between our respective program managers and directors.

Mr. Chairman, the complications that arose from the level of FY 1990 funds appropriated by Congress showed how changes in our budget planning affect not only the U.S. space program, but the programs of our international partners as well. These difficulties underscored the fundamental need for a multi-year appropriation. Our international partnership will stand us in good stead in the critical years ahead, and will be stronger if we can ensure the necessary funding stability for the Space Station.

Looking ahead, FY 1991 will be a key year for the Space Station Program. The preliminary design phase will be completed, and we will move on to detailed design and development activities in preparation for the planned Critical Design Reviews the following year. FY 1992 will mark the start of large-scale fabrication and testing of flight hardware, which will last for several years.

The pace of the Space Station program is driven by our plan to begin assembly in orbit in early 1995, establish permanently manned capability by mid-1997 and to complete the baseline Space Station in mid-1999. The Space Station does depend on maintaining strong national and international commitments to the program, and we are well on our way to making the Space Station a reality.

Full funding for the Space Station in FY 1991 is required to maintain the current program plan. Our current program funding requirements have been reduced to the minimum level

possible, while still meeting our key milestones and international commitments. Another reduction in program funding would again disrupt program planning and progress, and would result in delays in the assembly sequence, deferrals or deletions of program content, or some combination of the two. It would be a grave setback for the Space Station program, for the nation, and for our international partners if another program rephasing were forced by inadequate funding.

FY 1989 ACCOMPLISHMENTS AND FY 1990 ACTIVITIES

Attachment 2 shows how responsibility for developing the Space Station is divided among NASA centers and the international partners.

- Work Package 1 - Marshall Space Flight Center (MSFC), working with Boeing and various supporting development contractors, is responsible for U.S. pressurized modules, associated systems, logistics elements, and payload operations.

- Work Package 2 - Johnson Space Center (JSC), working with McDonnell Douglas and various supporting development contractors, is responsible for the central truss structure, resource node outfitting, various flight systems, crew training, and flight operations.

- Work Package 3 - Goddard Space Flight Center (GSFC), working with General Electric and various supporting development contractors, is responsible for the U.S. Polar Platform and Attached Payloads Accommodation Equipment (APAE).

- Flight Telerobotic Servicer (FTS) - Goddard Space Flight Center, working with Martin Marietta and various supporting development contractors, is responsible for the FTS.

- Work Package 4 - Lewis Research Center (LeRC), working with Rocketdyne and various supporting development contractors, is responsible for the Space Station's power systems.

- The European Space Agency is providing a pressurized laboratory module, the European Polar Platform, and the Man-tended Free Flyer.

- Japan is providing a laboratory module, an exposed facility, and an experiment logistics module.

- Canada is providing the Mobile Servicing System, including the Mobile Servicing Center, Special Purpose Dextrous Manipulator, and maintenance depot.

Let me now address our specific accomplishments of FY 1989 and activities that are in progress during the current fiscal year.

Work Package 1

In FY 1989, MSFC and the Work Package 1 team completed a comprehensive Preliminary Requirements Review. This review established requirements for preliminary design of the U.S. laboratory module, the habitation module, pressure shells and cupolas for the resource nodes, pressurized and unpressurized logistics carriers, the Environmental Control and Life Support System (ECLSS), the internal thermal control system, and the internal audio/video system. All subcontractors for this hardware were selected and brought on board.

Substantial progress was made on the preliminary design of all Work Package 1 elements and systems. Preliminary structural layouts and stress analyses of standard equipment racks, module utility distribution trays, and rack structural attach points were completed. Computer Aided Design systems were used to prepare three-dimensional packaging layouts for many of these items. High fidelity models were evaluated in the Work Package 1 Engineering Development Article, a true size, form, and fit mockup of the pressurized modules. Testing and evaluation of cupola design approaches were completed using this facility to verify viewing capabilities. Quarterly crew station reviews of the U.S. laboratory and habitation module overall layouts were conducted.

The ECLSS comparative testbed was activated. This involved installation of test stands, completion of facility support utilities, and delivery and installation of the air and water regenerative ECLSS subsystems. Testing was performed on units for potable water reclamation, urine processing, and carbon dioxide reduction. Also completed was the integrated air revitalization systems test in the Core Module Integrated Facility, which provided valuable data on subsystems interfaces and interactions, as well as on system-level performance characteristics.

Significant effort in FY 1989 was also devoted to planning for the ambitious ECLSS test program in FY 1990. This includes a test of intra-module air flow characteristics in a Space Station pressurized module, a test of the avionics air and fire suppression concepts, a test of the integrated water recovery system, early systems-level tests of the air revitalization and water recovery subsystems.

Several other subsystem development test programs were initiated to supply data required for the design process. Berthing mechanisms tests were conducted to evaluate a

redesigned alignment guide and to measure berthing loads. Over 80 successful firings were made in the Light Gun Gas Facility to provide data for the preliminary design of the meteoroid/debris shield and the selection of the module pressure shell material. Proof pressure testing of a prototype module yielded valuable data on bulkhead and cylinder deflections. In the internal audio/video system testbed, audio distribution audio recording techniques were simulated. This testbed was then upgraded for systems integration testing of hardware developed by subcontractors. The Software Preliminary Requirements Review was conducted on all Work Package 1 elements and systems, and a Software Production Facility was activated for use in software development. Finally, long lead procurements of Work Package 1 development hardware were initiated.

In FY 1990, the Work Package 1 team is completing preliminary design of its distributed systems. PDRs for these items will be held this year, followed by initiation of final design activities. Preliminary design of all other Work Package 1 hardware will continue.

Comparative testing of ECLSS technology demonstration hardware will be completed. The Phase III ECLSS tests in the Core Module Integration Facility, the Temperature Humidity Control Flow Test and the Concept Confirmation Test will also be completed. The ECLSS pre-development operations systems tests will be initiated. Test activities will continue for the audio/video system and berthing mechanisms. Audio/video system testbed activities will include breadboard testing of selected subcontractor design concepts, and breadboard testing of the distributed wireless audio antenna. Testing will begin on the internal electrical distribution system and hatch mechanisms. Neutral buoyancy tests of manned systems equipment will be conducted. Finally, the initial version of the Space Station payload user's guide is being completed this year.

Work Package 2

In FY 1989, JSC and the Work Package 2 team made substantial progress on the preliminary design of the truss structure, the mobile transporter, various other assembly and external maintenance systems, the propulsion element, the airlock, extravehicular activity systems, the guidance/navigation/control system, the external thermal control system, the communications and tracking system, the data management system, and the Crew Health Care System.

McDonnell Douglas selected Morton Thiokol as the subcontractor for design and fabrication of graphite epoxy tubes for the truss structure. Additionally, testing of the truss structure erectable joint is nearly complete. A single concept has been

selected for the Mobile Transporter structures interface. A full-scale mobile transporter track base and drive hinge assembly has been fabricated, and is being used for harness development and flexibility testing. A concept for the Space Station/Space Shuttle docking system was also developed.

Cupola mockups have been delivered to JSC, and flight crew evaluations of all designs are complete. A one-G mockup of the airlock was completed, and is being used to evaluate crew activity and hardware configurations. Another mockup for use in the water exertion test facility was also delivered. Simulating Zero-G tests have been conducted in the water tanks. Several space suits have been tested in the weightless environment with the Crew and Equipment Translation Aid (CETA) experiment to be flown on a shuttle flight later this year. In addition, some EVA/telerobotic testing was conducted at McDonnell Douglas.

Additionally, deployment of utility trays from a spool was demonstrated in the Water Emersion Test Facility. This simulated deployment will heavily influence the final design. Permeability tests are continuing on line materials and hoses for the McDonnell Douglas baselined non-metallic flexible lines.

The Thermal Ground Test Unit was delivered and installed at JSC. Testing of the thermal bus with heat pipe radiator panels has been completed. The Space Station heat pipe advanced radiator element (SHARE) was tested last year as a Shuttle flight experiment. This flight experiment demonstrated heat pipe isothermality under a thermal load, and revealed weaknesses in an early design of a heat pipe for the Space Station. The results of this test are being used to eliminate this weakness, and two redesigned heat pipes will be tested on the Shuttle's SHARE II mission in early FY 1991.

Proof of concept testing on the rotary fluid coupler was completed. A number of Data Management System (DMS) and Communications and Tracking critical breadboard circuits and models have been completed and are being tested. DMS kit prototypes were delivered to JSC, installed in the test bed, and have completed acceptance testing. In the GN&C area, McDonnell Douglas has selected Perkin Elmer for the star tracker. Fabrication of a space-to-space transceiver modem and video processor breadboard have been completed.

Medical requirements for the Crew Health Care System were baselined, as were specifications for outfitting the nodes and cupola. The environmental health care system mockup was delivered and is being evaluated. In addition, Ford Aerospace was awarded the mission support contract, and Link-CAE was awarded the training support contract.

In FY 1990, the Work Package 2 team is finishing the preliminary design of most systems and assemblies, and will conduct PDRs on these items before initiating detailed design. End item specifications for all systems and elements will be delivered. Procurement of long-lead items is being initiated.

Also this year, ground support equipment for ongoing test activities is being developed and processed. Neutral buoyancy testing of various articles of development hardware and EVA operations will continue. Preparations for the second heat pipe flight experiment on the Shuttle are in progress.

Work Package 3

In FY 1989, GSFC and the Work Package 3 team made considerable progress in the preliminary design of the APAE and various systems for the Polar Platform. Additionally, software development requirements were established, and development of a Software Production Facility was initiated. Documentation covering user design guidelines for on-orbit assembly was developed. Servicing requirements for Space Station payloads were collected and analyzed, and a servicing scenario database was developed for servicing simulations. Finally, preparations continued for the planned Capillary Pumped Loop Flight Experiment on the Space Shuttle.

In FY 1990, the Work Package 3 team will near completion of the preliminary design of its assigned flight hardware elements. Flight hardware development activities will be initiated for the Polar Platform tape recorder and propulsion subsystem after those subcontracts are finalized. The APAE hardware configuration is being finalized, and preliminary end item hardware and software specifications for the APAE and Polar Platform are being completed.

Also this year, testbeds for the development of the platform data system and power system testbeds are being initiated. Fabrication of thermal Flight Experiment hardware is beginning in support of the Capillary Pumped Loop flight experiment, and development of hardware for two other flight experiments is in progress.

Finally, Work Package 3 is being restructured to establish separate schedules and management interfaces for the Polar Platform and manned base APAE hardware in preparation for final transfer of management of the Polar Platform to the Office of Space Science and Applications at the end of this fiscal year.

Flight Telerobotic Servicer (FTS)

In FY 1989, GSFC and its FTS contractors completed Phase B studies, and Martin Marietta was selected to develop hardware

for the FTS and the two development test flights, DTF-1 and DTF-2, planned on the Shuttle in 1991 and 1993. The PDR for the first flight test was conducted last July.

In FY 1990, the FTS team is completing the subsystem design for DTF-1 and will build the hardware for this test flight. The required ground and flight software will also be developed. Initial delivery of the DTF-1 training system and simulator will begin in mid FY 1990. Control documentation for FTS interfaces with the Space Station, the Mobile Servicing Center, and user hardware is also being prepared. Additionally, a plan to actively promote the commercial application of FTS technologies is being developed and implemented this year.

Work Package 4

In FY 1989, LeRC and the Work Package 4 team made substantial progress on the preliminary design of power system components. Component PDRs were completed for the solar cells, battery cells, motor drives, array panel coatings, array bypass diodes, battery simulator, and solar array electrical simulator. Component CDRs were completed for the solar cells and the solar array electrical simulator. The end-to-end architecture of the power distribution and management system was also defined.

The Power Management and Distribution (PMAD) architecture was changed from alternating current to direct current for primary distribution. A common switch design was selected for all secondary switches. Breadboard switches were developed and are being tested at Rocketdyne. Preliminary test results look encouraging. 160 Vdc switches were also tested at LeRC as a part of the supporting development efforts. Construction of the Rocketdyne Space Power Electronics Laboratory facility was completed, and the facility activation was started. Tests of the PMAD control system were conducted, and computer controls were programmed.

Additionally, solar cell production was initiated last year for engineering development and qualification testing. Several hundred cells were delivered from each of two vendors for evaluation. Initial lots of flight-type 8 x 8 cm solar cells were calibrated using high altitude balloon flights. These calibrated cells form the basis for acceptance testing and grading of production solar cells. Fabrication of the solar array electrical simulator was initiated, and photovoltaic array panel/plasma interaction tests were conducted. The tests used 2-panel solar array circuits with a plasma simulating the low earth orbit environment. Results confirmed that the operating voltage of 160v is below the arcing threshold. The test also showed the array ground is not a driving factor in determining the primary distribution

ground scheme. The dynamic electrical response of the solar array circuit was also tested.

Rocketdyne also developed and tested the Radiant Fin Heat Exchanger concept for ORU box cooling. The radiant fin concept provides heat transfer without requiring tight mechanical mating of flat plates as required in more conventional approaches. This approach facilitates ORU removal and replacement by robotic means. The final delivery of NiH2 cells was placed on life test at NASA LeRC. A total of 39 cells of various designs from three manufacturers were placed on test, and 3,500 cycles were achieved by the end of FY 1989. These results will be factored into the final selection of SSF cell design parameters. Two NiH2 cell vendors also completed a nickel electrode optimization program and electrode testing is in progress.

Construction of the Power Systems Facility was also completed, and a full-scale prototype solar dynamic concentrator was received for testing in this facility. The tests increased confidence that a solar dynamics concentrator can be aligned on earth, disassembled, and then reassembled in orbit without realignment. 10,000 hours of test were completed on the solar dynamics receiver to demonstrate compatibility of the thermal energy storage salt with the containment vessel. Also, tests on a single receiver tube with energy-storage canisters verified the thermal energy storage concept used in the baseline solar dynamics system receiver design.

In FY 1990, the Work Package 4 team will near completion of the preliminary design of its flight hardware elements. Detailed design of hardware and software for the power management and distribution system will begin. Fabrication of breadboard components of this system will be completed, and testing will be initiated. Detailed design of the photovoltaic module will begin, and development testing of its assemblies and components will continue.

Also this year, fabrication of engineering models of the battery and DC electronics will begin. Neutral buoyancy testing of the photovoltaic module beta gimbal and the solar dynamic concentrators 3-panel assembly is being initiated.

Operations and Utilization Capability Development

The objective of the Operations/Utilization Capability Development (OUCD) program is to develop the operational ground facilities, systems, and capabilities required to conduct Space Station ground and flight operations.

In 1989, OUCD activities focused primarily on design of facilities. Kennedy Space Center conducted the CDR for the Space Station Processing Facility, and initiated procurement

of the Test, Control, and Monitor System. Marshall Space Flight Center began design of the Payload Operations and Integration Center and the Payload Training Center. Johnson Space Center began design of the Space Station Control Center and Space Station Training Facility. Design of Engineering Support Centers at all four work package centers was also initiated.

In FY 1990, Kennedy Space Center is procuring computer-aided design and engineering equipment, continuing design of the Test, Control and Monitor System, and procuring equipment for outfitting the Space Station Processing Facility. Marshall Space Flight Center is continuing design of the Payload Operations Integration Center and the Payload Training Center, and is continuing development of payload analytical integration software tools and processes. Johnson Space Center has completed design of the Space Station Control Center, the Space Station Training Facility and the Space Systems Automated Integration and Assembly Facility. Construction of these facilities will be initiated. Johnson is also continuing operations assessments, contingency scenario analysis, and operations requirements development. Operations support contracts have already been awarded this year. In addition, all four work package centers are continuing design of their respective Engineering Support Centers.

Over the past year, considerable progress has also been made in determining roles and responsibilities of the NASA centers and international partners during mature operations. Functional Control Documents have been drafted to define the support structure required at each center and international partner to implement each of the key operation and maintenance functions. The NASA centers and international partners have participated in two joint reviews of these documents.

Management and Integration

We have also thoroughly reassessed our program management approach, and have made some improvements in our development organization. The Space Station management team has been strengthened by the addition of some of NASA's most experienced managers from the Space Shuttle program. The Level I organization at NASA Headquarters has been modified as a result of the Office of Space Station merging with the Office of Space Flight. This merger was undertaken to ensure that NASA's manned space flight programs are completely coordinated.

The Space Station Freedom Program Office (Level II) has been modified to increase the efficiency and effectiveness of its management and integration role in the program. Level II system and element integration has been co-located with the two largest Work Packages, Johnson Space Center and Marshall

Space Flight Center. A major consideration in this decision was that the experienced technical talent we require is more readily available at these two NASA centers.

Level II is responsible for program control, integration, systems engineering, and operations/utilization integration. Contractors for these efforts include Grumman for the Space Station Engineering and Integration Contract (SSEIC), Lockheed for the Software Support Environment (SSE), and Boeing for the Technical and Management Information System (TMIS).

In FY 1989, program engineering and integration activities focused on resolving issues raised in the previous year's Program Requirements Review, and on developing data needed to support preliminary design efforts at the work package centers. Level II also carried out a detailed technical audit of the program content in each work package against program level baseline documents. In preparation for the upcoming series of PDR's, Level II made significant progress in establishing an automated requirements management capability and in refining program engineering analysis tools and processes. Associate Contractor clauses were incorporated in the prime contracts to facilitate direct integration of hardware and software schedules between the four prime contractors.

Level II, supported by the Space Station Engineering and Integration Contractor (SSEIC), progressed toward completion of the requirements for the manned base and polar platform flight and ground systems, including critical resource allocations for weight and electrical power. System engineering analyses were performed and major design trade offs were conducted which resulted in a revised baseline assembly sequence and key functional requirements for the stages of assembly. The results of these accomplishments in FY 1989 provided the basis for stage definition of selected stages in FY 1990.

Also in FY 1989, the TMIS development organization created a program-wide electronic mail, calendar, and file transfer capability that now links the NASA electronic mail system with the Space Station contractors and the international partners. Computer programs were developed to assist in document control, assembly sequence/resource allocation, action tracking, and other tasks. In addition, development work was initiated on the Computer Integrated Engineering capability, a tool to enhance program design integration. SSE accomplishments in FY 1989 included delivery of Software Production Facility components to the work package prime contractors, and definition of the standard software development architecture for SSE host computers and work stations for all work package contractors.

In FY 1990, the Space Station Freedom Program Office, with the support of SSEIC, will perform analysis related to the overall configuration and assembly sequence, system architecture, and performance requirements. Allocations of power, weight, and other resources are being baselined. Integrated preliminary design will be accomplished on the manned base and key stages of assembly. The SSEIC will play a significant role in supporting the Space Station Freedom Program Office with the planning of, participation in, and support of the Space Station Freedom Program's Preliminary Design Review process which is a major Program milestone to be completed in December 1990. Additionally, work will be accomplished on an end-to-end integration plan, a multilateral utilization study and a trial payload manifest.

TMIS will establish engineering databases, develop technical applications, and implement the program-wide drawing and model library. These applications and databases, along with the Computer Integrated Engineering System, will be utilized heavily during the Program's design phase. In addition, TMIS will provide critical data processing support to the Preliminary Design Review. The SSE contractor will outfit additional Software Production Facilities at selected subcontractor locations, will deliver numerous software development tools and documentation standards, will complete the next SSE Operational Increment, and will install an integrated environment for software development, test and verification.

Transition Definition

Transition Definition activities ensure that the baseline Space Station can evolve consistent with projected user requirements, national space policy, our international agreements, and program constraints. Advanced System Studies are undertaken to define Space Station capabilities required to support anticipated future needs and missions such as the Human Exploration Initiative. Advanced Development tasks are focused on applying automation and robotics technologies to improving productivity and reducing future operations costs. These activities are essential to ensure that critical hooks and scars are provided in the baseline to enable evolution to meet future requirements.

In 1989, Advanced System Studies tasks identified preliminary reference configurations for baseline Space Station evolution and recommended associated design provisions and technology requirements. Possible revisions to the baseline Space Station were analyzed as part of the configuration/budget review process. Study support for the Human Exploration Initiative is beginning. Advanced Development tasks focused on demonstration of advanced automation applications for status monitoring, fault detection and isolation for Space Station flight and ground systems. Performance enhancements

for FTS control algorithms were also made. Strong emphasis was placed on automation and robotics technologies that could reduce manned extravehicular and intravehicular activities during assembly and early Station operations.

Pending funding approval, in FY 1990, Advanced System Studies tasks will build on the knowledge gained of both maturing system designs and requirements posed by identified evolution requirements. Design requirements and accommodations ("hooks and scars") for distributed system capacity growth and new technology insertion will be identified. Advanced Development tasks will continue to emphasize advanced automation, robotics, and other technologies to improve flight and ground system productivity and to reduce long-term operations costs. Continued development and demonstration on Space Station engineering testbeds will refine design accommodations to enable increased use of automation and robotics in both the baseline and evolutionary Space Station.

International Partners' Activities

In FY 1989, NASA and the international partners moved forward in a number of areas. The Phase C/D/E Memorandum of Understanding (MOU) between NASA and the Government of Japan entered into force in 1989 (MOUs with ESA and Canada entered into force in 1988). Japan also selected the hardware development contractors for the Japanese Experiment Module (JEM), and conducted its preliminary requirements review for this module.

The European Space Agency (ESA) began evaluating responses to its space segment industrial proposal, and began preliminary definition of its ground infrastructure requirements. ESA also conducted parallel studies of two polar platform concepts and selected its baseline concept.

Canada completed the preliminary design of the Mobile Servicing Center and conducted a PDR before moving into detailed design activities.

In FY 1990, NASA and its partners plan to establish, under the Multilateral Coordination Board, two panels called for under the agreements to coordinate long range planning for Space Station utilization and operations. We will also complete initial baselining of joint design and development requirements documentation. All the partners will participate in the Space Station program-level PDR. Canada will conduct a joint Mobile Servicing Center PDR with us. Japan will be conducting its PDR for the JEM, in addition to initiating Phase C/D contractor activities. ESA will finalize its Phase C/D contractor approach.

Space Station User Activities

As a world class research laboratory in space, Space Station Freedom will offer users unparalleled opportunities for space science and technology research. Facilities in the pressurized laboratories will support extensive microgravity and life science research, while attached payloads will offer research benefits to many science and technology disciplines.

Space Station Freedom's diverse user community is refining its plans to conduct life sciences research. By the end of FY 1991, NASA's Office of Space Science and Applications will complete definition studies on the space Biology Initiative, and will begin its full development phase. This project provides for U.S. facilities on the space Station dedicated to space physiology, gravitational biology, exobiology, and closed ecological life support system testing and research. Users will continue definition of a centrifuge facility that will provide variable gravity and one-gravity control capabilities for in-flight experimentation. Definition activities are beginning on the Biomedical Monitoring and Countermeasures initiative, which will help us develop techniques to maintain optimum crew health and performance during extended stays on orbit. The Spacelab Life Sciences (SLS-1) mission in 1990 will be the first in a series of Shuttle/Spacelab missions dedicated entirely to life sciences, and will focus on investigation of biomedical responses to weightlessness.

The Space Station's microgravity environment will allow users to conduct unprecedented experiments in the areas of material, fluid, and combustion science. Definition of several facilities for this research is the primary user-related activity this year. These definition activities focus on facilities for: heating, biotechnology, modular combustion, fluid physics and dynamics, advanced protein crystal growth, and modular containerless processing. Meanwhile, final preparations are underway for the first International Microgravity Laboratory Spacelab mission in December. This is one of the many precursor flights on the Shuttle that will allow the user community to further refine technology and research facility requirements for Space Station utilization.

Finally, through the use of attached payloads, Space Station Freedom will offer opportunities to make extended measurements and observations to a variety of other disciplines, while offering the capability for servicing on-orbit. Space Station user activities during 1990 focus on continuing definition of end-to-end science operations requirements and on providing Space Station designers with appropriate levels of information regarding science requirements. Definition studies will continue for candidate attached payload instruments selected in 1989.

FY 1991 RESEARCH AND DEVELOPMENT BUDGET REQUEST

Space Station Freedom's Research and Development (R&D) funding requirements for FY 1991 and the following two years reflect the progress being made in the development program. The detailed design phase of the program begins in FY 1991, and development hardware fabrication and testing activities must accelerate accordingly to support CDR's in the following year. Also, key ground facilities required for testing, training, integration, and control must be completed in order to support schedule. The request supports the planned growth in the development effort to stay on track for beginning assembly in orbit in March 1995.

The Space Station's funding requirement in FY 1991 is $2.451 billion. Additionally, we are requesting a three year advance authorization and appropriation that would also provide $2.907 billion in FY 1992 and $3.031 billion in FY 1993. This legislation would greatly increase programmatic stability, provide continuity of the development process, and protect the integrity of our commitments. Our request is consistent with the proposed development cost ceiling of $13 billion in 1984 dollars.

The chart on the next page shows how the FY 1991 Space Station budget request is broken down by program area. There are two significant differences between this budget request and previous requests. First, beginning with FY 1991, the Space Station budget no longer contains funding for the Polar Platform project. Second, this request contains, for the first time, funding for Human Exploration Initiative study activities in the Advanced Programs budget line. These activities will examine Space Station capabilities and technologies that may be required to support manned missions to the Moon and Mars.

ACTIVITIES SUPPORTED BY FY 1991 R&D FUNDING

Let me now discuss our specific plans for FY 1991, and what we must accomplish to maintain our first element launch milestone in early 1995.

Work Package 1 ($522 million)

In FY 1991, the Work Package 1 team will be heavily involved in the final design of its distributed systems in preparation for their CDR in early FY 1992. The preliminary design of the U.S. laboratory module will be completed, its PDR will be conducted, and final design activities will begin in preparation for a CDR in FY 1992. Engineering manpower for design and analysis activities will increase to support the FY 1992 PDRs for the habitation module and logistics carriers. Other key activities include procurement of hardware for

FY 1991 R&D Budget Request for Space Station

(Amounts In $ Millions)

Work Package 1	522
Work Package 2	873
Work Package 3	34
Flight Telerobotic Servicer	106
Work Package 4	368
Total Work Packages and FTS	1,903
Operations/Utilization Concept Development	255
Management and Integration	248
Advanced Programs	
- System Studies and Advanced Development	16
- Human Exploration Initiative	20
Operations	9
Total FY 1991 R&D Budget Requirement	2,451

development and qualification testing of the Environmental Control and Life Support System (ECLSS), and testing of the integrated ECLSS subsystems in a simulated module. Structural test articles for the nodes and cupolas will be fabricated and used to conduct structural loads and environmental tests.

Supporting development activities at Marshall Space Flight Center include providing test facilities and related support (such as meteoroid/debris protection testing, seal development, berthing mechanism testing, module pressure/structural testing, and environmental testing) for prime contractor development efforts. Also included are ECLSS systems analyses, supporting development testing and simulations, and materials properties assessments, including metallurgical support and lubricant evaluation. Other planned supporting development activities include systems engineering and integration, as well as implementation of a comprehensive technical and management information system.

Work Package 2 ($873 million)

The Work Package 2 team will focus on the CDR for the Data Management System in support of the first delivery of a data management system kit in FY 1991. Engineering development units for the assembly work platform, the mobile transporter, the astronaut positioning system, the communications and tracking system, the hyberbaric hatch, and the thermal control system will be delivered. Testing of these units will be conducted to support the program CDR the following year. Engineering design and evaluation of the guidance, navigation, and control system, mechanical systems, and other systems will continue.

Supporting development activities will continue in preparation for the CDR. At Johnson Space Center, supporting development provides for all the test and facility manpower required for independent analytical support to assess system design viability, test article outfitting, and testbed operation. For example, supporting development activities for the truss assembly will include integrated loads and dynamics analysis, structural testing, materials usage assessment, structural assembly and berthing verification, and hypervelocity impact testing. The manpower, laboratories, computational capabilities, and hardware required for these analytical tasks will be supplied by supporting development contractors.

Work Package 3 ($34 million)

After the Polar Platform is transferred out of the Space Station program, the primary item remaining in this work package is the Attached Payloads Accommodation Equipment (APAE). The preliminary design of the APAE will be completed, the PDR will be conducted, and detailed engineering design and analytic work will begin.

Goddard Space Flight Center's supporting development activities include defining APAE common equipment, providing data support services and technical discipline support to structural/thermal analysis, defining contamination and monitoring requirements, and performing risk assessments.

Flight Telerobotic Servicer (FTS) ($106 million)

The major FTS activity next year will be integration and launch of the first development test flight on the Shuttle. The primary objective of this test flight will be to evaluate the FTS design and man-machine interfaces through the use of a manipulator system, a preliminary workstation, and software. DTF-1 hardware and software testing will receive particular emphasis, and astronaut training on the DTF-1 training system and simulator will begin after completion of checkout. PDR's for the second development test flight and the FTS itself will also take place, and FTS components will undergo continued development and test.

Supporting development activities include development of equipment for crew training, flight operations support, and integrated flight simulations. Efforts will continue on applications procedure development and studies supporting potential enhancements.

Work Package 4 ($368 million)

The Work Package 4 team will continue work on the development and qualification of the solar cells and blankets. Energy storage assembly qualification cells will be fabricated and tested. Detailed design and testing of module items such as electrical equipment assemblies and beta gimbals will continue. Power management and distribution (PMAD) system components and orbital replacement units will undergo detailed design during FY 1991. End-to-end testing of PMAD components will be completed in late FY 1991, and hardware will be delivered to Lewis Research Center in preparation for the electrical system integrated test planned the following year.

Supporting development activities include independent verification of the prime contractor systems engineering and integration efforts. Also included is the provision of a facility to conduct electrical integrated testing, "fleet leader" battery testing, and system validation of the photovoltaics module.

Operations/Utilization Capability Development ($255 million)

Johnson Space Center will complete requirements definition and design of the Space Station Training Facility and the Space Station Control Center. Construction of these facilities will begin, with the objective of having them ready in 1993.

Related hardware and software acquisition activities will also begin. Software development activities of the operations planning and analysis system will continue at an increased pace.

Marshall Space Flight Center will define design and operations requirements for the Payload Operations Integration Center to provide an initial operational capability in 1995. A request for proposals will be released for systems development and procurement of the Payload Training Center, which is scheduled to have an initial operational capability in 1995.

Kennedy Space Center will begin significant equipment purchases, and will increase activity in planning, scheduling, systems software development, and manpower buildup for the Test, Control, and Monitor System (TCMS) and the Space Station Processing Facility. The TCMS PDR and the logistics information system CDR will be completed. Requirements for the Space Station Hazardous Processing Facility will be baselined.

Level II will refine facility requirements for Space Station operations and utilization in the Functional Control Documents, which will provide a basis for coordinating operations and utilization planning activities of the NASA centers and international partners.

Management and Integration ($248 million)

Management and integration activities will continue to focus on engineering integration, expansion of the Software Support Environment (SSE), and expansion and operation of the Technical and Management Information System (TMIS).

The Space Station Engineering and Integration Contractor (SSEIC) will assist NASA in a broad range of activities required to prepare for completion of the program PDR in December 1990 and the CDR in FY 1992. These system engineering tasks include top-level stage definition for key stages of assembly, analysis of stage performance and assessments of the design against the requirements. The system integration tasks include integrated scheduling and development of verification plans, engineering data bases, and interface control documentation. Program plans will be developed for system safety and quality assurance, launch package integration, on-orbit assembly and checkout, and integration with the Space Shuttle. The SSEIC will have an increased role at the field centers based on the relocation of the systems and element integration responsibilities to JSC and MSFC. For example, the SSEIC will support the Level II offices at these centers in preparing and maintaining Interface Control Documents, Architecture Control Documents, and Baseline Configuration Documents.

The SSE operational capabilities will be expanded by increasing and improving existing capabilities in the Software Support Environment Development Facility and the Software Development Facilities at contractor sites. In FY 1991, the Software Production Facilities at the field sites will be supported and additional facilities put in place as required.

Incremental delivery of TMIS products will continue. Efforts will continue toward completing electronic bridges needed to link together contractors, NASA centers, and domestic and international users. Technical and resource information management, tracking systems, and databases will continue to be developed, with emphasis on those elements required to support the program PDR and CDR.

Advanced Programs ($36 million)

In FY 1991, Advanced Development and Advanced System Studies activities will ensure that the baseline Space Station will have the capability to add new functions, expand planned resources, and avoid obsolescence through technology upgrades. Advanced Development tasks will continue to emphasize advanced automation, robotics applications, and technology development to improve flight and ground system productivity and reduce long-term operations costs. Activities planned include: demonstration of knowledge-based automated subsystem control for flight and ground systems applications and cost effective software test/integration; and, demonstration of FTS operator/robot shared control in support of both the DTF-1 flight experiment, and the demonstration of large robot control from a remote site. Advanced System Studies will continue definition of an evolution reference configuration, including analyses to identify baseline configuration impacts and operational compatibilities associated with the more capable Station. Continued analyses are planned of the Station's distributed systems to define and document critical evolution design requirements before hardware construction.

The Human Exploration Initiative will likely evolve Space Station Freedom beyond its baseline configuration capabilities. Supporting potential transportation requirements may necessitate additional structure, power, servicing, and other capabilities. $20 million of the Advanced Programs request is for exploration technology to begin to study systems-level enhancements, and to begin the advanced development and preliminary design of the following crucial systems: Space Station-based EVA and high pressure suits; solar dynamic power; expanded hybrid power distribution and management system; and advanced propulsion. A special study on concepts of advanced automation and robotics for potential space transfer vehicle assembly, checkout, and servicing will be initiated to determine an appropriate mix of automation and EVA that may be needed to support potential

mission operations. The focus of these efforts will be to ensure that the essential hooks and scars to support HEI are identified and incorporated into the baseline program. Planning for these activities is being closely coordinated with the Exploration Technology program.

Operations ($9 million)

FY 1991 is the first year for funding operations. The early operations activity includes the establishment of a logistics system and spare parts for the flight systems. The FY 1991 funding in this area will allow for the procurement of long-lead materials required to begin establishing the spares inventory. These procurements need to be initiated in FY 1991 to ensure that spares are available to support launch site processing as well as on-orbit operations for early assembly flights. As the Space Station Program moves into its operational phase, the operations budget will provide for sustaining engineering, logistics, crew training, hardware processing, and other operational costs.

OTHER BUDGET REQUIREMENTS

Research and Program Management

NASA's Research and Program Management (R&PM) budget funds the salaries of NASA personnel assigned to the Space Station program. This area of the budget also supports our travel requirements, which are considerable due to the wide geographic dispersion of the program, including the international partnership. Consistent with the increasing pace and scope of program R&D activities, NASA requires increases in both R&PM funding and the manpower ceiling for the Space Station program. As the efforts of the Space Station contractors expand, NASA direction and oversight must also grow to ensure that R&D funds are spent wisely and efficiently.

Construction of Facilities

Several projects in the Construction of Facilities (CoF) budget are critical to the Space Station program. In 1991 we will begin construction of the Space Station Processing Facility at Kennedy Space Center and the Neutral Buoyancy Laboratory at Johnson Space Center. We will also continue construction of the Space Station Control Center, and complete construction of the Space Station Training Facility at Johnson. Full funding for these facilities is essential to support our plans to begin Space Station launch and assembly operations in early 1995.

Assured Crew Return Vehicle

NASA's Space Transportation Capability Development R&D request for FY 1991 includes funding for Phase B definition studies of an Assured Crew Return Vehicle (ACRV) for the Space Station. The ACRV definition studies are required to support future decisions on its use with the Space Station.

KEYS TO SUCCESS IN FY 1991

- Funding Adequacy and Stability - Implementing our plan to begin assembly in early 1995 and complete the baseline Space Station by mid-1999 depends on maintaining an adequate and stable funding profile. At the very least, inadequate funding would disrupt the development effort, delay our schedule, and increase program costs.

- Preliminary Design Review Schedule - The program will be conducting more than 80 subsystem PDR's in 1990 leading up to a system-level PDR in December 1990. The intensity and manpower requirements across the program will be focused on this accomplishment.

- Systems Engineering and Integration - The program will define and baseline element-to-element interfaces and element-to-distributed system interfaces Baseline Configuration Documents will define hardware locations within modules and on the truss structure. Functional Control Documents will define the flight-to-ground system architecture. Architecture Control Documents that were baselined last fall will continue to be updated as necessary to reflect approved changes in the upcoming PDRs.

- Resource Control - Weight and power controls were baselined at the work package level last fall. Continued assessment of these controls and baseline control of crew time and volume will occur this year.

- Debris Protection - Debris protection criteria will be baselined and reflected in the PDR this year. In addition, a debris protection plan will be developed that minimizes the likelihood of debris impact for objects larger than the design criteria selected.

SUMMARY AND CONCLUSIONS

In closing, I would like to emphasize four key points.

First, our objectives for Space Station Freedom have not changed. For our science program, Freedom offers a laboratory for research in many scientific disciplines and a platform for

instruments to look out at the universe as well as back toward the Earth. For technology development, Freedom will be a unique national facility - a testbed for evaluating technologies, procedures, and design approaches for potential application in future space systems. For our exploration program, Freedom's manned base represents the establishment of a permanently manned oupost in space and a stepping stone for the missions of the future.

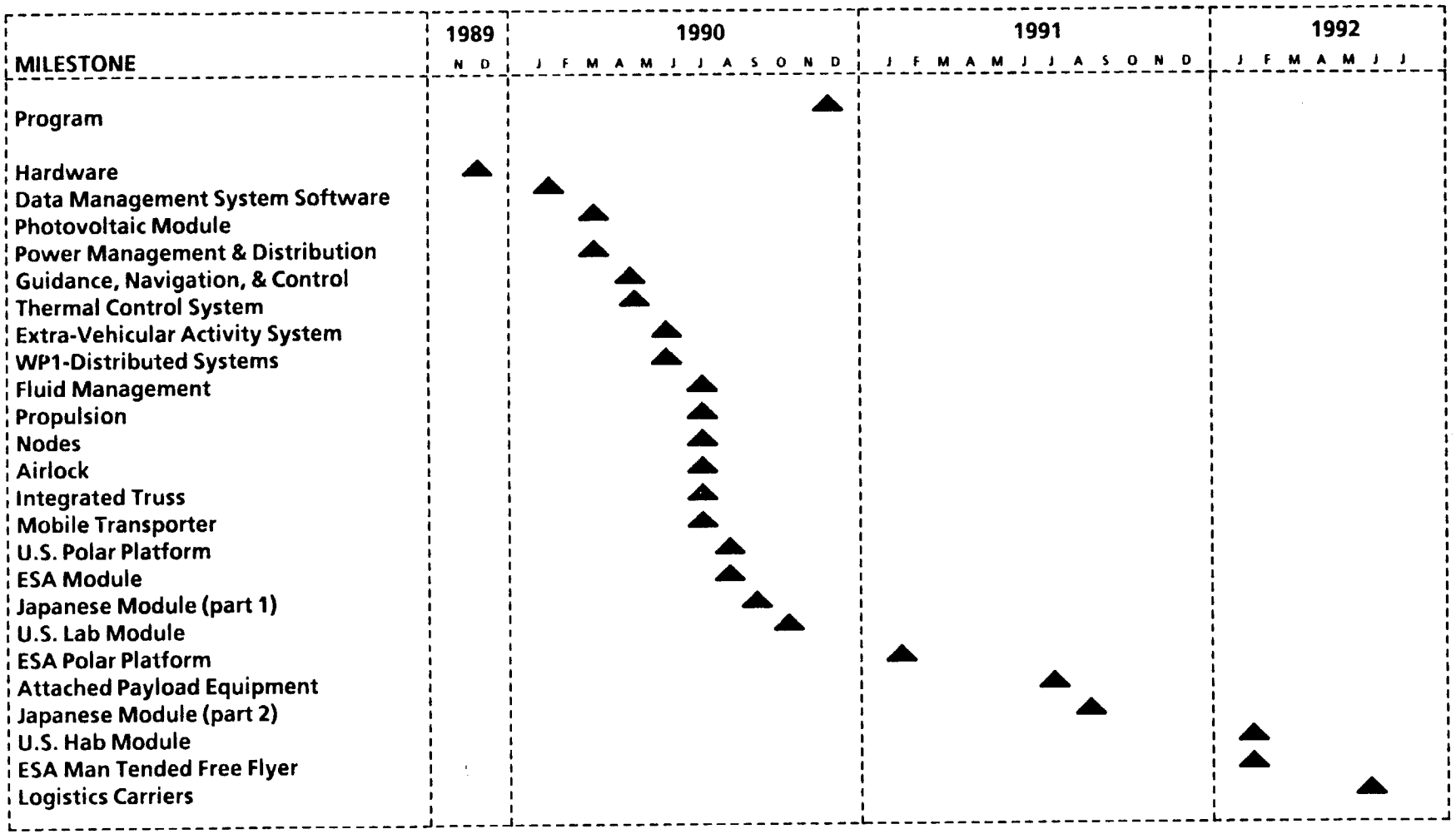
Second, our progress to date on the Space Station has been substantial. The First Element Launch milestone is one year closer now than it was at our last budget hearing before this Subcommittee, and our design and development effort is moving forward accordingly on all fronts. The Space Station is developing hardware and necessary infrastructure. Many of our important accomplishments to date involve tangible hardware items, including hundreds of breadboards, proof-of-concept development items, testbeds, test articles, mock-ups for human factor analysis, and technology demonstration hardware.

Third, some program adjustments have been required in the last year, but the basic integrity of the Space Station program is intact. The reduced funding for FY 1990 and the resulting need to minimize near-term program costs, technical risks, and schedule risks forced some changes in program plans, primarily involving the schedule for outyear assembly milestones and addition of planned capabilities. Despite these recent adjustments, however, the fundamental objectives of the Space Station program are unchanged, and the planned capabilities of the Space Station are maintained.

Finally, as you well know, full funding for FY 1991-1993 is necessary if we are to avoid additional disruptions in the Space Station development effort. The stability that is required can only be provided by multiyear funding. This Committee has understood this reality and demonstrated its strong support for the program by approving the Space Station's existing multiyear authorization. Renewal of this multiyear authorization and initiation of a multiyear appropriation are essential if we are to complete the baseline Space Station before the start of the twenty-first century.

Mr. Chairman, this concludes my prepared statement. I look forward to answering your questions.

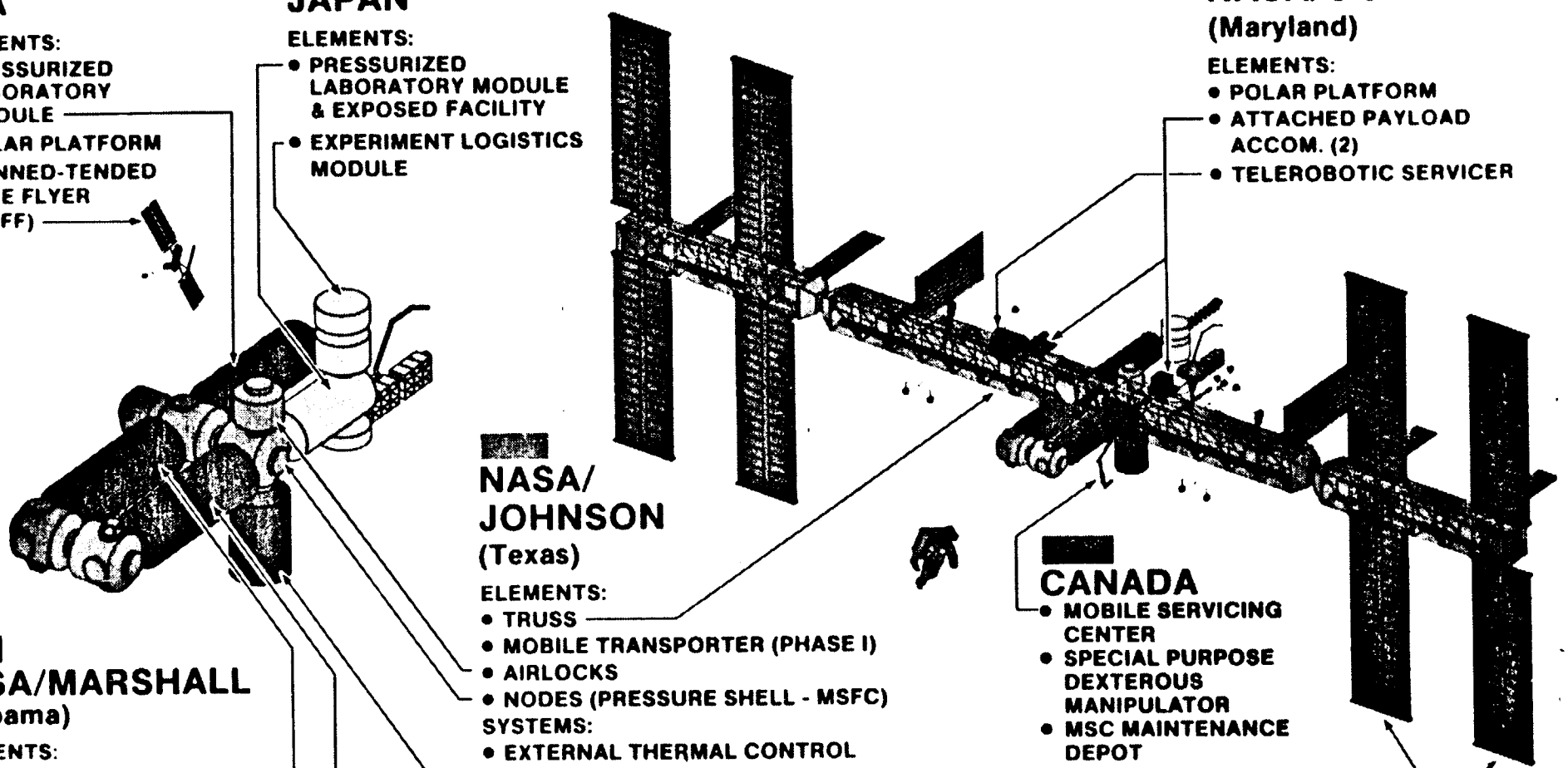
SPACE STATION
PRELIMINARY DESIGN REVIEWS



Attachment 1

OSS-12102
2/15/90

SPACE STATION FREEDOM



ESA

ELEMENTS:
- PRESSURIZED LABORATORY MODULE
- POLAR PLATFORM
- MANNED-TENDED FREE FLYER (MTFF)

JAPAN

ELEMENTS:
- PRESSURIZED LABORATORY MODULE & EXPOSED FACILITY
- EXPERIMENT LOGISTICS MODULE

NASA/GODDARD (Maryland)

ELEMENTS:
- POLAR PLATFORM
- ATTACHED PAYLOAD ACCOM. (2)
- TELEROBOTIC SERVICER

NASA/JOHNSON (Texas)

ELEMENTS:
- TRUSS
- MOBILE TRANSPORTER (PHASE I)
- AIRLOCKS
- NODES (PRESSURE SHELL - MSFC)

SYSTEMS:
- EXTERNAL THERMAL CONTROL
- EVA
- DATA MANAGEMENT
- COMMUNICATIONS & TRACKING
- GUIDANCE, NAVIGATION & CONTROL
- PROPULSION (THRUSTER TD BY MSFC)
- NSTS/SS ATTACHMENT SYSTEMS

NASA/MARSHALL (Alabama)

ELEMENTS:
- PRESSURE SHELLS FOR NODES
- LABORATORY MODULE
- HABITATION MODULE (OUTFITTING TD BY JSC)
- LOGISTICS MODULE (PRESS & UNPRESS)

SYSTEMS:
- ECLSS
- INTERNAL THERMAL CONTROL
- INTERNAL AUDIO & VIDEO

CANADA

- MOBILE SERVICING CENTER
- SPECIAL PURPOSE DEXTEROUS MANIPULATOR
- MSC MAINTENANCE DEPOT

NASA/LEWIS (Ohio)

ELEMENTS:
- POWER MODULES - PV

SYSTEM:
- ELECTRICAL POWER DISTRIBUTION

OSSTT 88E

Attachment 2